TEST OF THE DWBA DESCRIPTION OF TRANSFER REACTIONS AT INTERMEDIATE ENERGIES BY MEASURING A COMPLETE SET OF SINGLE NUCLEON AND ELASTIC SCATTERING DATA

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Mechanisms for the simplest one-nucleon transfer reactions viz., (p,d) and (d,^{3}He) reactions, have been the subject of much experimental and theoretical work. The Distorted Wave Born Approximation (DWBA) theory has been successful in describing these reactions at low energies. At intermediate energies these reactions have been thought not to be well described by DWBA theory because of the large momentum transfer involved. In many cases DWBA has failed to reproduce experimental data, especially analyzing power angular distributions.[1] Before a definite conclusion is reached, whether or not DWBA works at intermediate energies, all required ingredients which go into the standard DWBA have to be vigorously tested.

This present experimental work at IUCF is designed to test several ingredients of DWBA at intermediate energies. A complete set of angular distributions of differential cross sections and analyzing powers for the single nucleon transfer reactions ^{87}Sr($\vec{p}$,d)^{86}Sr and ^{206}Pb($\vec{d}$,^{3}He)^{205}Tl at energies E_p = 94.2 MeV and E_d = 79.4 MeV and for elastic scattering of p + ^{87}Sr at E_p = 94.2 MeV, d + ^{86}Sr at Ed = 88.0 Mev, d + ^{206}Pb at E_d = 79.4 MeV have been obtained. Differential cross section angular distribution has also been obtained for ^{3}He + ^{205}Tl elastic scattering at 78.4 MeV.

These two particular reactions were chosen as the radial wave functions of the valence nucleons, $\pi(3s_{1/2})$ and $\nu(1g_{9/2})$ respectively are precisely known from elastic electron scattering.

Optical model analyses using Woods-Saxon (WS) forms for the potential have been carried out and the best fit optical model parameters for all the elastic scattering data have been obtained. Following is the procedure used to extract deuteron parameters on ^{206}Pb. Optical-model calculations with both relativistic and non-relativistic kinematics were used and it was found that the calculations with relativistic kinematics yield a better χ^2 value by almost a factor of 2. First we started with a standard Woods-Saxon (WS) shape of the potential with the global deuteron parameters from Ref. 2 and obtained a set of best fit parameters. The shape of the potential was then altered by using other forms of potentials like Woods-Saxon with an imaginary spin-orbit term (WS + ISO), squared Woods-Saxon (WS^2), and squared Woods-Saxon with imaginary spin-orbit term (WS^2 + ISO). Each time when the shape of the potential is changed there is an improvement in the χ^2 value as can be seen from Table 1. The number of parameters in all these cases is very small compared to the number of experimental data points. Fig. 1 shows the optical model fit obtained for the deuteron elastic scattering data on ^{206}Pb, with the various types of potentials. The forms of the real and imaginary parts of best fit WS and WS^2 are shown in Fig. 2.

The distorted waves generated from these different potentials have definitely an influence on the DWBA calculations in predicting the shape and magnitude of

TABLE I

Optical model parameters for ^{206}Pb + d at 79.4 MeV incident energy

Potential form	V	r_0	a_0	W_s	W_D	r_W	a_W	V_{SO}	r_{SO}	a_{SO}	W_{SO}	r_{WS}	a_{WS}	χ^2/point σ	χ^2/point A_y	χ^2/point total
global WS[a]	77.76	1.17	0.812	6.76	7.7	1.29	0.919	4.66	1.07	0.6				122.9	124.2	123.6
best fit WS	79.22	1.183	0.811	6.28	9.31	1.281	0.855	4.95	1.063	0.805				34.5	66.0	50.3
WS+ISO	79.87	1.178	0.824	7.55	8.31	1.306	0.813	4.593	1.083	0.611	-0.679	0.935	0.216	27.5	24.0	26.2
WS^2	86.9	1.367	0.6	6.51	8.75	1.256	0.959	5.898	1.084	0.747				22.8	38.8	30.8
WS^2 +ISO	87.72	1.308	0.606	7.05	8.04	1.27	0.956	5.532	1.061	0.670	-0.582	0.924	0.226	6.8	13.3	10.0

a) Ref. 2

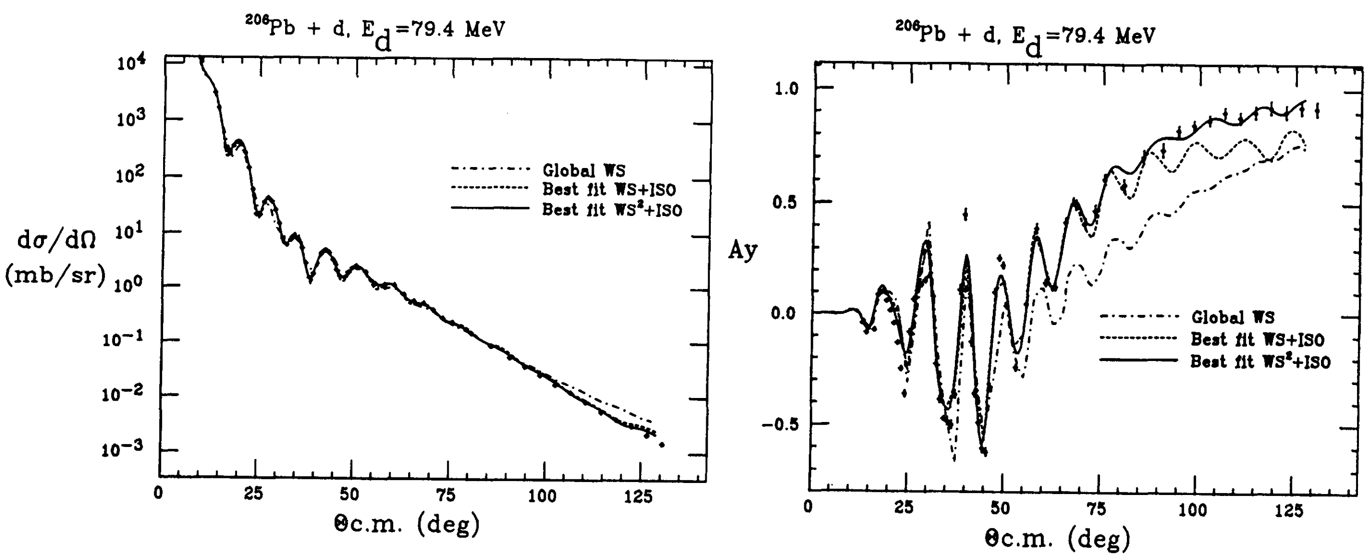

Figure 1.

the angular distributions. Fig. 3 shows the predictions of the standard DWBA for the ground state transition of $^{206}Pb(d,^{3}He)^{205}Tl$ reaction. There is a reduction in the magnitude of the cross section maximum at 8°, between the predictions from global parameters and our best fit WS parameters. There is another reduction in the cross section when a squared WS potential form is used. On the other hand, the inclusion of an imaginary spin-orbit term has negligible effect on the calculated transfer cross section.

Thus in order to remove the ambiguities associated with the shape of the optical potentials and to obtain a best possible shape of the true potential, another method[3] is being used for analyzing phenomenlogically, the real and imaginary parts of the optical potentials. This method consists of adding to the conventional WS potential an extra potential given by a Fourier-Bessel series. The coefficients of these series will be

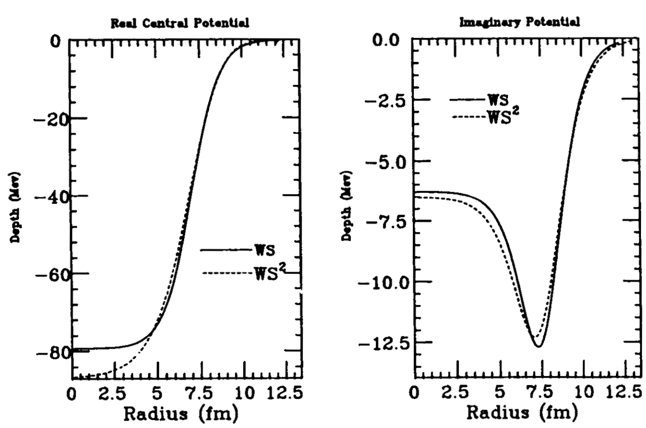

Figure 2.

determined by a least-squares fit to the data. Although this method increases the number of parameters, it will still be a very small number compared to the number of experimental data points.

1) J.R. Shepard, E. Rost and P.D. Kunz, Phys. Rev. C 25, 1127 (1982).

2) W.W. Daehnick, J.D. Childs and Z. Vrcelj, Phys. Rev. C 21, 2253 (1980).

3) E. Friedman and C.J. Batty, Phys. Rev. C 17, 34 (1978).

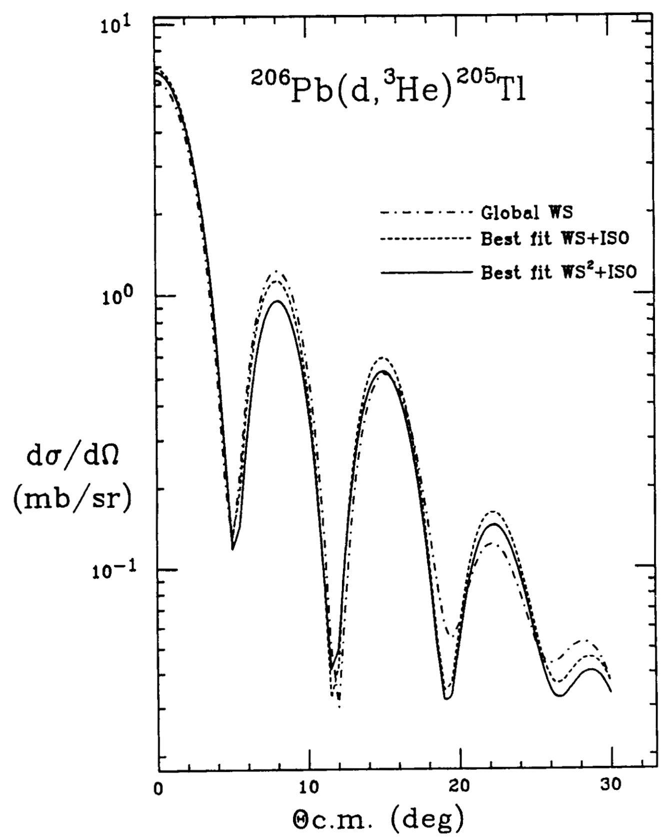

Figure 3.